

The University of Chicago

ECOLOGICAL SURVEY OF THE
BELLA COOLA REGION

A PART OF THE DISSERTATION SUBMITTED
TO THE GRADUATE FACULTY IN CANDIDACY
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF BOTANY

By
BLANCHE McAVOY

Private Edition, Distributed by
THE UNIVERSITY OF CHICAGO LIBRARIES
CHICAGO, ILLINOIS

Reprinted from
THE BOTANICAL GAZETTE, Vol. XCII, No. 2, 1931

The University of Chicago

ECOLOGICAL SURVEY OF THE
BELLA COOLA REGION

A PART OF THE DISSERTATION SUBMITTED
TO THE GRADUATE FACULTY IN CANDIDACY
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF BOTANY

By
BLANCHE McAVOY

Private Edition, Distributed by
THE UNIVERSITY OF CHICAGO LIBRARIES
CHICAGO, ILLINOIS

Reprinted from
THE BOTANICAL GAZETTE, Vol. XCII, No. 2, 1931



ECOLOGICAL SURVEY OF THE BELLA COOLA REGION

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 419

BLANCHE McAVOY

(WITH FIVE FIGURES)

Introduction

The Bella Coola Valley is an east and west valley lying wholly in the coast mountains of British Columbia, at the latitude of $52^{\circ} 21'$. It is the landward extension of a series of channels, Fitzhugh, Burke, and North Bentnick, which cut through the Coast Range from the Pacific Ocean north of Vancouver Island. These channels are typical fiords whose grandeur rivals that of the fiords of Norway. They range from one to three miles wide, with nearly parallel sides and with few indentations or constrictions. Their almost perpendicular walls rise from the water's edge precipitously, and in places culminate in snow capped peaks. These mountain sides drop off just as abruptly beneath the surface of the water as they rise sheer above it, and in some places 300 fathoms have been measured and deeper places may occur.

The study recorded in this paper was made during the summers of 1926 and 1928.

GEOLOGY

Concerning the geology of the Coast Mountains, LINDGREN (6) states:

At the end of the Jurassic or the beginning of the lower Cretaceous intrusions began on a large scale along the coast accompanied by marked uplift: magmas of great volume were intruded forming a great chain of batholiths now exposed by erosion all along the Pacific from lower California to Alaska. In comparison with this intrusion all earlier and later phenomena fade into insignificance. The magmas crystallized into coarse granitic rock but its average composition is not that of granite but of a granodiorite. The rocks are uniformly gray or whitish.

SPENCER (9) believes that the ranges are remnants of an uplifted and much dissected peneplain that was once continuous with the

belt of interior plateaus. He assigns their elevation to post-Eocene times. DOLMAGE (2) says that the Coast Mountain system consists of batholiths that are 100 miles in width. He states also (3) that in the Bella Coola region Table Mountain and Canoe Crossing Mountain, which are about 30 miles east up the Bella Coola Valley, mark the boundary between the Coast Mountains and the interior plateaus.

In regard to the rivers that move westward through the Coast Mountains, SPENCER (9) is of the opinion that they were antecedent to the uplift of the mountains and have maintained their westward course during the rise of the mountains.

During the Pleistocene the valley glaciers moved westward. Glacial grooves on the south side of North Bentnick arm, not far from the mouth of the Bella Coola River, and grooves at the top of Canoe Crossing Mountain show that the ice moved in a westward direction and was at least one mile deep. DALY (1) says that the Scandinavian region was depressed by the load of ice during the Pleistocene, that both North America and Europe sank under the load of ice, and that since that time the continents have been rising slowly. Small rocky benches along the coast of British Columbia may be evidence of a postglacial rise of the depressed coast.

CLIMATE

Places on or near the coast have their greatest rainfall in the winter, as compared with the summer maximum for places in the interior. Also the coast has an abundant rainfall as compared with the meager rainfall of the interior. Near the coast local conditions may have a great effect on the amount of rain. This effect is shown in the well known differences between Vancouver (58.76 inches) and Capilano Creek (129.46 inches). These two places are less than 10 miles apart. Bella Coola with 46.2 inches and Ocean Falls with 144.21 inches, despite the fact that they are only about 50 miles apart in a direct line, also illustrate this fact. At Bella Coola the greatest rainfall occurs in October and November, with 8 inches as the November average. This heavy rain in the valley, together with the melting of early snow in the mountains, causes a yearly autumn flood in the Bella Coola River.

The average monthly temperatures for Bella Coola vary from 26° F. for January to 61° F. for July for a 10-year interval. At the eastern end of the valley the temperatures are lower in winter and higher in summer than they are at the western end. The amount of rainfall decreases so much at the eastern end of the valley that in some cases gardens are irrigated. No official figures are available.

In summer the Bella Coola Valley is well lighted and the days are long, but in winter there are a few weeks when the sun does not rise high enough to shine over the mountains, and at those times the sun can be seen only when it passes notches in the mountains.

Bella Coola Valley

The Bella Coola River is formed by the junction of the Whitewater and the Atnarko rivers, just east of Table Mountain. From here it flows in a westerly direction for about 40 miles, where it empties into North Bentnick arm. The Whitewater comes from glacial fields, and many of the smaller streams that empty into the Bella Coola River from the south carry large amounts of glacial débris. Like most streams that carry too heavy a load, the Bella Coola River is a braided stream at the western part of the valley. For most of the distance the main channel is close to the foot of the mountains that border the north side of the valley. During the summer months the river is white and thick with glacial silt, but in the winter months the water is clear and less in amount.

The mouth of the Bella Coola River is on the south side of the eastern end of North Bentnick arm, and the Necleetsconney River, coming out of a valley that opens from the north, also empties into the eastern end of North Bentnick arm but north of the mouth of the Bella Coola River.

The water-borne glacial silt of the Bella Coola River is filling in the eastern end of North Bentnick arm, between the mouths of these two rivers, at a rate that has been estimated at about 0.5 foot per year. The tide comes up over the western part of this newly deposited land, which is known locally as the tide flat (fig. 1).

The Bella Coola is a typically U-shaped valley, 1-3 miles wide, hemmed in by mountains that range 4000-10,000 feet high. In some places the floor of the valley has been cleared for farming (fig. 2).

Forests of Bella Coola Valley

WHITFORD and CRAIG (10) state that the valleys that connect the interior plateau with the ocean are a part of the physiographic features of British Columbia that are favorable to economic utilization of forest products. The Bella Coola Valley is one of these favorably located valleys, but up to the present time no widespread cut-

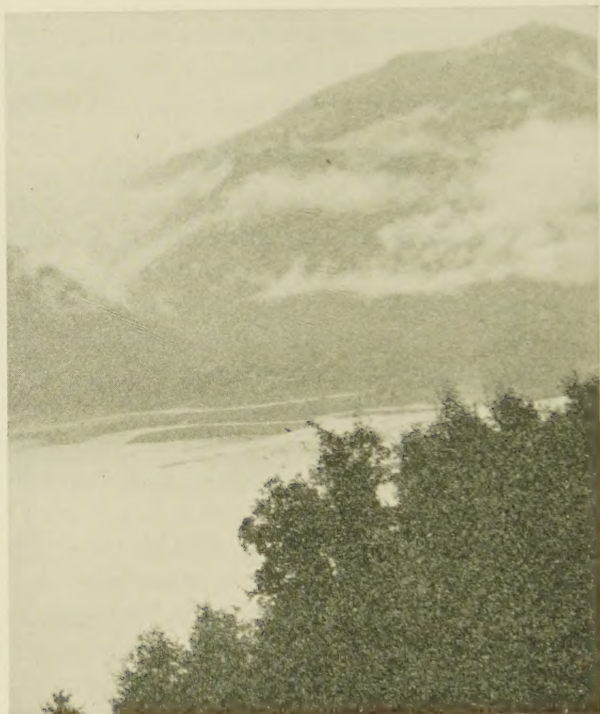


FIG. 1.—Junction of North Bentnick arm and tide flat

tings of the forests have occurred, and much of the valley is in its native condition. This made an ecological survey of the vegetation under natural conditions easily possible.

WHITFORD and CRAIG (10) have mapped the five important forest tree species occurring in the Bella Coola region. These are *Pseudotsuga mucronata*,¹ *Thuja plicata*, *Picea sitchensis*, *Tsuga hetero-*

¹ All plants except *Populus tacamahaca* have been named according to HENRY, J. K., Flora of Southern British Columbia. Specimens have been checked with herbarium specimens in the Field Museum, Chicago.

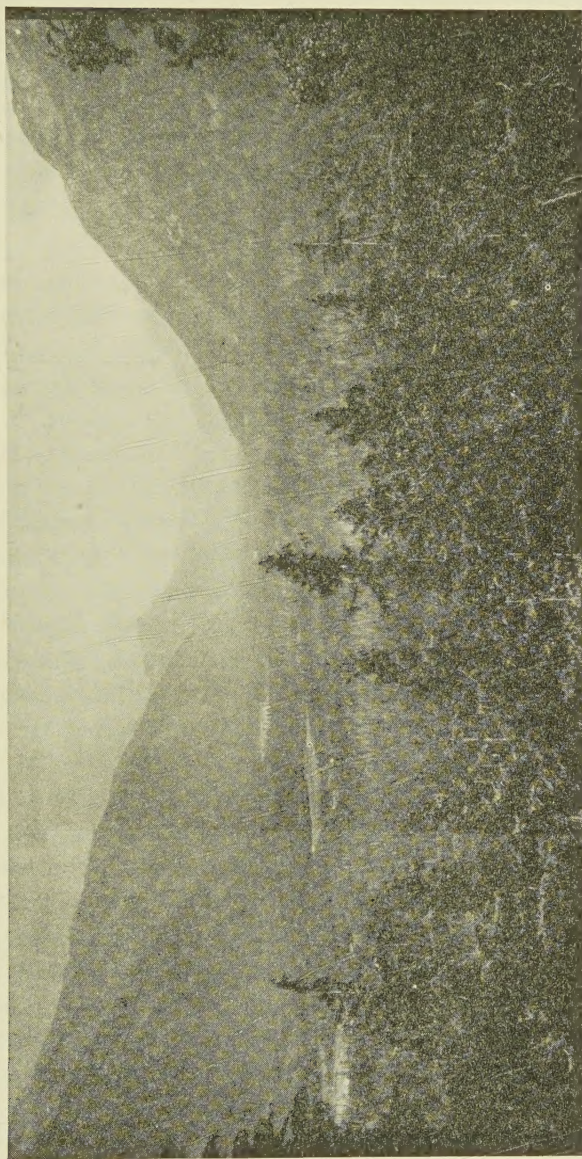


FIG. 2.—Bella Coola Valley looking eastward and showing cultivated areas

phylla, and *Abies amabilis*. The first four make up the climax forest of the valley floor. The last is not found in the valley but is an important montane species. The climax forest does not occur everywhere in the region, but is common on the floor of the western end of the valley. Undergrowth is not common and the forest floor is covered with a thick growth of *Hylocomium splendens*.

In many places in the coniferous forest there are old trees of *Alnus rubra* and *Populus trichocarpa*. These species are not able to reproduce themselves under the conifers, but are pioneer hangovers in the coniferous forest. The percentages of the different species of conifers in the climax forest are somewhat dependent on the location of the forest in the valley. The nearer the forest is to the tide flat the greater will be the percentage of *Picea sitchensis* and the smaller will be the percentage of *Pseudotsuga mucronata*. The closer the forest is to the southern side of the valley the closer it is to the rim of the mountains that hem in the valley, and the later the lie of snow in spring with a greater percentage of *Tsuga heterophylla*. About 7 miles east of North Bentnick arm a careful count showed 32 per cent of *Thuja plicata*, 21 per cent of *Tsuga heterophylla*, 20 per cent of *Pseudotsuga mucronata*, 19 per cent of *Alnus rubra*, and 8 per cent of *Picea sitchensis*. The trees of such a forest are not close together but the shade is dense. The trees are covered with a heavy growth of mosses and lichens.

Pinus contorta is found as a pioneer on thin rocky soil at the eastern end of the valley. The true subclimax of the region is *Pseudotsuga mucronata*. In addition to its occurrence on the mountains, which will be discussed later, this species occurs in almost pure stands on the floor of the eastern end of the valley. It is also important in the mixed forest. The eastern end of the valley is drier than the western end, and therefore favors the growth of this species. However it is not replacing itself, for under the giant trees of *P. mucronata* the undergrowth consists of *Thuja plicata*, *Tsuga heterophylla*, and *Picea sitchensis*. It is evident that on areas that are now covered with *Pseudotsuga* there will be in the future a mixed coniferous climax forest. *Picea sitchensis* forms a pure stand at the back of the tide flat, and extends for half a mile before it merges into the mixed forest of the valley floor.

Tsuga heterophylla forms a large percentage of the mixed forest along the south side of the valley under the shade of the mountains. Both *T. heterophylla* and *T. mertensiana* grow in solid stand in some of the north and south valleys that join the Bella Coola Valley, especially in the Salloompt Valley where the hemlock forests cover the glacial terraces. Hemlocks are common wherever the snow lies until late in the spring.

In some of the north and south valleys *Abies grandis* occurs with the hemlocks. It occupies the moister and more shaded areas. *Tsuga* in pure stand or with a mixture of *Abies* forms a post-climax in the region. The forest of the mountain sides and the succession of alpine vegetation will be discussed later.

Studies of plant succession

1. VEGETATION OF TIDE FLAT

When the swiftly moving Bella Coola River, heavily laden with glacial silt, meets the incoming tide twice each day at the western end of the valley, the current is slowed down and the water spreads out and drops its load. In this way the tide flat is being built up rapidly, and new land is developing for plants to occupy. Many small streams flowing toward North Bentnick arm are visible only during low tide. Drift wood, brought down the river during times of flood, is scattered all over the tide flat. High tide covers the entire western end of the flat, and no woody vegetation occurs.

In all probability the history of the vegetational development of the tide flat is the same as in all parts of the western end of the Bella Coola Valley. It will, therefore, be interesting to follow the development of vegetation on the flat. A careful study of the vegetation was made on a small island south of the main channel of the Bella Coola River.

The greater part of the western end of the tide flat belongs to a vegetation zone which may be called zone 1. It is an area that is covered longest and deepest by high tide. It extends to the east along the little streams. The plants form tiny hummocks, and between these hummocks the water is a few inches deep even during low tide. The plants are rooted in a white, sticky, silty mud. During low tide the water moves slowly over the flat toward North Bentnick

arm, and during high tide it stands over the area to a depth of several feet. The zone is exposed to the fullest light when the tide is out. The area is dominated by *Hippuris tetraphylla* and *Plantago maritima*. In little ponds on the tide flat *Scirpus validus* may be found, but it is not strictly a plant of the first zone. The pH of the zone ranges from 6.6 to 7.0.

Zone 2 is a rather wide area, lying immediately above the preceding. High tide covers it to a depth of 1.5-2 feet. During low tide

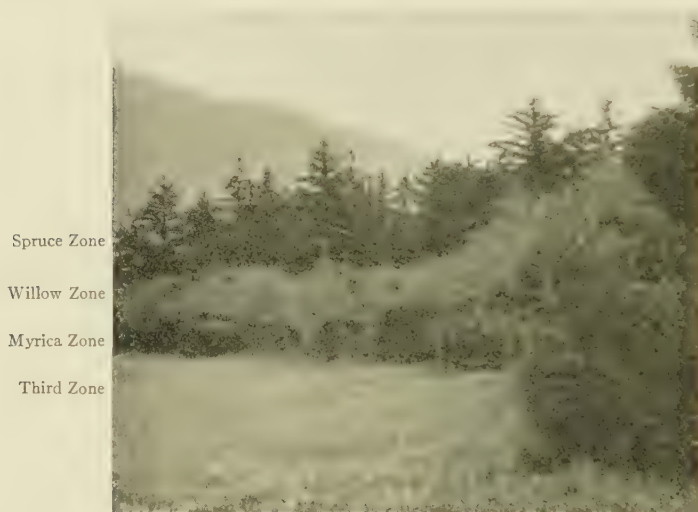


FIG. 3.—Zonation of vegetation back of tide flat

it is water soaked and muddy. It has a grassy aspect and is dominated by *Eleocharis palustris*. *Ranunculus cymbalaria* is abundant, and in some parts of the zone *Potentilla anserina* from the zone above is encroaching upon it.

As the ground gets higher it is barely covered by ordinary high tide and is well drained and comparatively dry at low tide. Zone 3 is a marginal band in front of the first zone of woody plants, dominated by *Carex barbarae*, *Potentilla anserina*, and *Trifolium sibiricum*.

Only exceptionally high tides that are blown in by western storms go higher than zone 3. Above this area on higher land is zone 4, in

the form of a band of woody shrubs dominated by *Myrica gale*, which range in height from 3 to 4 feet. Under the *Myrica* are herbaceous plants such as *Hordeum nodosum*, *Lathyrus palustris*, *Potentilla anserina*, and mosses.

Immediately behind the *Myrica gale* is zone 5. It consists of a narrow band of *Salix lasiandra*, *S. scouleriana*, and *Lonicera involucrata*. These shrubs and small trees range in height from 8 to 10 feet. There is moss on the ground, but the shade is so dense that herbaceous vegetation is not prominent. Young spruce trees are found occasionally under the willows. Behind the willows is an almost pure stand of *Picea sitchensis*. In some places the trees are so close together that other vegetation is almost completely absent and this species is the sole dominant. The spruce zone extends for almost half a mile before it merges into the mixed coniferous forest of the valley floor (fig. 3).

2. SUCCESSION ALONG STREAMS

Since much of the Bella Coola Valley has been made by glacial silt deposited by fresh water, it will be interesting to follow the succession of plants along the streams.

At one place, where 50 m. of new land is known to have been deposited by a stream in the last 25 years, a transect was made so as to extend in a due north and south direction, with the stream at the northern end (fig. 4). When the water of the stream stands at ordinary summer height, a gravelly bank rises to a height of about 0.5 m. above the level of the water. During the periods of summer flood the entire bank is covered with water, and during the fall floods water stands much higher.

Immediately above the bank and paralleling the stream is a belt of young specimens of *Alnus rubra*. This belt is about 3.5 m. wide and extends along the stream for many meters. In places this belt is interrupted. The trees are 1.5–2.5 m. high, with an average height of 2 m. The diameters of the trees are 1–3 cm. The ground on which these trees are growing is somewhat higher than that immediately to the south of it. It is clear that the area occupied by the alders was once a bar, and that the stream flowed at one time through the depression or panne to the south.

The panne is an open area exposed to the full light of the sun. While apparently bare of trees, it is here that the tree seedlings are the thickest. Two species intermingle, *Salix* and *Populus trichocarpa*. No alders are found on any part of the panne (fig. 4). At the



FIG. 4.—Transect across new land made by stream, using 1 m. as unit of measure

present time the panne is beyond the reach of summer floods, but may be covered by the water of fall floods. It is about 15 m. wide, and at the south side the ground rises to a higher level. Near the bank are several small clumps of alders that are about the same size as those along the stream.

The higher land to the south of the panne came into existence as a large island. The trees here are of medium size, scattered, and produce much shade. Many of the largest trees are *Populus tri-*

chocarpa. On the northern side of this land are many medium sized alders. There are a few willows in the depressions, but the trees that are of the most importance from the standpoint of succession are small specimens of *Picea sitchensis* and *Thuja plicata* that are growing in the shade of the larger *Alnus* and *Populus* trees. These indicate that the future vegetation of the area will be a mixed coniferous forest.

At the south side of the area is an old stream bed. The banks on each side of it are rather steep, and on the south bank are old, large alders. In the stream bed are large willows, *Salix lasiandra* and *S. scouleriana*.

It seems proper to draw the conclusion that where new land is formed by stream action, the first trees to grow on areas that are out of the water sufficiently to be well drained are *Alnus rubra*, and on areas that are constantly damp are *Salix* and *Populus trichocarpa*. Moreover, it may be concluded that when sufficient shade is produced to protect the seedlings of *Picea sitchensis* and *Thuja plicata*, these species begin to grow, and if sufficient time is allowed they become the dominant trees of the area. In places that are shaded by the mountains, *Tsuga heterophylla* is found in similar situations.

At the edges of streams which are neither depositing nor cutting to any appreciable degree, shrub vegetation may grow to the very edge. Such shrubs are *Sambucus racemosa*, *Aruncus sylvester*, *Ribes acerifolium*, *Fatsia horrida*, *Rubus spectabilis*, *Cornus stolonifera*, and *Rubus parviflorus*. With the shrubs are large luxuriant clumps of *Asplenium cyclosorum*. Above the water on well rotted logs one can usually find *Phegopteris phegopteris*. With the shrubs are small coniferous trees. Where coniferous trees have had time to get full grown along a stream that has been neither cutting nor depositing through long periods of years, the climax forest conifers grow down to the water's edge. In many places along the Bella Coola and Nutsatsum rivers the species of *Tsuga*, *Thuja*, and *Picea* grow so close to the edge of the stream that branches hang into the water.

3. SUCCESSIONS IN MUSKEGS

Beavers have played a large part in the ecological development of the Bella Coola Valley. They have built their dams along the

sloughs and across the smaller streams that enter the Bella Coola River, causing the water to spread out and flood the forested areas. Many of the trees have been cut down or killed and the flooded areas have become well lighted. Back from the centers of the flooding the water has spread out, but it has never been deep enough to kill the trees. They have lived on in a less luxuriant way, and there has been produced a water logged area which is well shaded. Thus beavers have produced two new kinds of areas where two distinct types of plant succession may be found. Light is the main factor that determines the differences in these successions: those in the beaver ponds are primary and those in the water logged areas are secondary.

In the deep water of the beaver ponds are submerged algae and mosses. Where the water is more shallow there are pads of *Nymphaea polysepala*, and in still shallower water large areas covered with *Zannichellia palustris* occur. Closer to the shore there is generally a widespread association of *Equisetum fluviatile*. Animals that range the valley, especially cows, keep the *Equisetum* well cropped, and it is not so abundant now as it was when the settlers first came to this region. In the shallower water the *Equisetum* gives way to *Sparganium multipedunculatum*, and shoreward from that two associations of *Carex* succeed each other. *Carex rostrata* grows in deeper water than does *C. salina*. *C. salina* is found more abundantly around the beaver pond at the western end than it is farther east up the valley.

Around the beaver ponds there is usually developed a muskeg where the following plants are found: *Scirpus microcarpus*, *Carex festiva*, *Glyceria pauciflora*, *Sphagnum* sp., and *Polytrichum* sp.

In the moss, either as islands or on the shore of the ponds, there is a well developed shrub association made up of *Myrica gale*, *Spiraea douglasii*, *Lonicera involucrata*, and *Rubus parviflorus* with *Potentilla palustris*. Occasionally, if there is enough shade, *Lysichiton kamtschaticense* may get started. Under the shrubs are seedlings of the deciduous trees and the conifers that originally occupied the area. Almost always the largest seedlings are those of *Alnus rubra* and *Salix*. *S. lasiandra* and *S. scouleriana* are usually both present. The smaller seedlings are those of *Thuja plicata*, *Picea sitchensis*

and *Tsuga heterophylla*. Back of the shrubs is a narrow association of willows and alders in which are growing coniferous trees. It is easy to see that in a few years the flooded area will be covered with the coniferous forest that is native to the region.

Floating logs in the ponds form centers for plant development. It is on these logs that one may always find *Vaccinium canadense*. The logs are usually covered with a thick growth of moss in which are seedlings of *Picea* and *Thuja*. Where the logs are near the edge of the water and are rather dry, there is a good growth of *Cornus canadensis*. Around the shaded margins of the beaver lakes there is a rank growth of *Lysichiton kamtschaticense*. Where the water has never been deep enough to kill the trees, a shade is cast that is sufficient to prevent the growth of light-demanding species. In such places one plant is always dominant, *Lysichiton kamtschaticense*. It comes in where the water is at least a foot deep, and it is still vigorous where there is no standing water and where the ground is firm enough to walk over. In deep water there are algae in addition to the skunk cabbage. *Sphagnum* helps to build a substratum, and on it *Conocephalum* grows.

In order to determine the frequency of the species in the association that had developed on the shaded and water-logged area (8, 4), there were used three thin bars of wood fastened together and arranged so as to fold up and open out. When opened and placed on the ground so as to form three sides of a square meter, the species of plants within the square so formed were noted. By studying a number of sample areas that did not overlap, the percentage of square meters in which each species was found was noted, and these percentages were considered the frequencies of the species in the association.

Such a frequency count gave the following percentages: *Lysichiton kamtschaticense* 96, *Mnium* 60, *Sphagnum* 56, other mosses 48, *Phegopteris dryopteris* 40, *Clintonia uniflora* 40, *Fatsia horrida* 36, *Circaea alpina* 36, *Asplenium cyclosorum* 28, *Hylocomium splendens* 20, *Streptopus amplexifolius* 20, *Alnus rubra* 16, *Equisetum sylvaticum* 12, *Menziesia ferruginea* 12, *Moneses uniflora* 8, *Cornus canadensis* 8, *Picea sitchensis* seedlings 8, *Acer glabrum* seedlings 4, and about four other species in about 4 per cent of all the quadrats ex-

amed. This study shows that *Lysichiton kamtschaticense* and certain mosses are the dominant species in areas that are shaded and water-logged. Where the ground is drier *Fatsia horrida* and the seedlings of the conifers are important.

4. SUCCESSION ON ROCK SLIDES

In the Bella Coola region rock slides are common and are important in the base leveling of the mountains. Where the granodiorite of the mountains approaches granite in structure, the slides are made of huge blocks of rocks; but where the mountains are composed of an easily disintegrated rock, the talus slopes consist of small pieces. On the slides made of the huge blocks of rock, lichens are a much more prominent part of the vegetation than they are on the finer talus slopes. There are four or five species of crustose lichens that are commonly found on the rocks of the Bella Coola region.

In places the crustose lichens may be overgrown by a foliose lichen that grows so close to the rock that it is hard to loosen. Sometimes lichens like *Sticta* follow the crustose lichens, and sometimes *Umbilicaria* comes early in the succession. Frequently *Pilophorus cercolus* follows the smallest lichens, being common on all the rock slides of the region. Where succession has gone further there are many kinds of fruticose lichens, including *Stereocaulon paschale*, *S. prunetosum*, *Ramalina farinacea*, *Thamnolia vermicularis*, *Cladonia gracilis*, *C. bellipodophora*, *C. coccifera*, and perhaps others. In time these fruticose lichens are invaded by *Selaginella rupestris*, *Rhytidium robustum*, *Racomitrium canescens*, *Gymnostomum*, and many other mosses. *Hylocomium splendens* is found in a few of the most shaded and mesophytic parts of rock slides, but it is not at all common.

Rooted in the mosses on the rocks are clumps of *Polypodium vulgare* and *Cryptogramma acrostichoides*. About 25 clumps of *Asplenium trichomanes* were discovered, but it may be more abundant. With it is *Lycopodium lucidulum*. *Campanula rotundifolia* is common. Where soil has accumulated, that is, near the bottom of slides, *Pteris aquilina* var. *lanuginosa* and *Aspidium spinulosum* var. *dilatatum* occur. Where shade is afforded, *Vaccinium parviflorum* occurs; where the mosses have built up a sufficient substratum *Linnaea*

borealis may be found. In the crevices between the rocks of a slide the vegetation makes greater progress, and *Pseudotsuga* comes early. Where shade occurs the seedlings of *Thuja plicata*, *Tsuga heterophylla*, and even a few specimens of *Picea sitchensis* may flourish.

On one of the slides at the western end of the valley on a western exposure is a dense growth of *Gaultheria shallon*. It grows in the shade of trees and other shrubs, and is found only on the western exposure of one mountain in the Bella Coola region, although it is common along the channels, especially near Ocean Falls. With this may be found *Vaccinium parviflorum* and *Spiraea discolor*.

About 1885, on South Bentnick arm near a mine owned by Mr. F. Jacobsen, there occurred a big rock slide. Mr. Jacobsen said that 40 years later the lower part of the slide was completely grown up to *Thuja plicata*, *Tsuga heterophylla*, *Picea sitchensis*, and *Alnus rubra*, and that the trees were 12-14 inches in diameter.

5. SUCCESSION ON CUT-OVER LAND

Clearing in the Bella Coola Valley may be complete or partial, and the degree of clearing is important in determining the type of secondary growth. At the back of the tide flat the spruce forest has been cleared in places to allow grazing space for animals. In some places *Trifolium repens* and *T. fimbriatum* cover the ground. *Agrostis alba* is found with *Trifolium* in some places. Other herbaceous plants in the cleared areas are *Lilium parviflorum*, *Sanguisorba sitchensis*, *Prenanthes alata*, *Trientalis arctica*, *Potentilla anserina*, *Asplenium cyclosorum*. Some parts of the area are becoming overgrown with shrubs, *Rosa nutkana*, *Amelanchier florida*, *Spiraea douglasii*, and *Lonicera involucrata*. Under these shrubs there are seedlings of *Picea sitchensis*. Clumps of half-grown *Picea* are found on all parts of the cleared area at the back of the tide flat.

Where the land was covered with a mixed conifer forest, before it had been cleared for use as pasture land, the plants of the secondary growth represent three general groups, those of the former forest, those of the pasture, and those of the new forest that is establishing itself.

A count on one pasture that is reverting to brush showed that *Rubus viburnifolia* has a frequency of 90, *Poa pratensis* 80, *Populus*

tacamahaca 70, *Trifolium repens* 60, *Cornus stolonifera* 40, *Rubus parviflorus* 35, *Alnus rubra* seedlings 30, *Galium triflorum* 50, *Cerastium vulgatum* 25, *Rumex acetosella* 25, *Sambucus racemosa* 25, *Phegopteris dryopteris* 20, *Ribes divaricatum* 15, *Urtica* 15, *Asplenium cyclosorum* 15, *Spiraea douglasii* 10, *Plantago major* 10, *Picea sitchensis* seedlings 10, *Thuja plicata* 5, *Salix* 15, *Montia sibirica* 5, and *Maianthemum bifolium* var. *kamtschaticum* 5.

The plants of the former forest are in the minority, and are represented by such plants as *Montia sibirica*, *Maianthemum bifolium* var. *kamtschaticum*, and *Phegopteris dryopteris*. The pasture plants are represented by *Poa pratensis* and *Trifolium repens*. The plants which represent the new forest which is in process of becoming established are *Rubus viburnifolia*, *R. parviflorus*, *Populus tacamahaca*, and seedlings of *Alnus rubra*, *Picea sitchensis*, and *Thuja plicata*.

The first plant to invade a pasture which is not being used sufficiently is *Rubus viburnifolia*. Then the seedlings of *Populus tacamahaca* get started and grow into tall trees. In the shade of the deciduous vegetation soon come the seedlings of the conifers *Tsuga*, *Picea*, and *Thuja*. In some places the poplars are 30 feet tall, *Alnus* almost as tall, and the conifers under them about 5 feet high. All this has come on land that was cleared less than 30 years ago, indicating that land becomes reforested rapidly. When the trees have not been cut down in sufficient numbers to clear the ground, and where the partially cleared ground is well shaded, the conifer seedlings that are native to the soil soon replace the trees that were cut.

At the back of the tide flat *Picea sitchensis* seedlings follow on the partially cleared land. Farther east *Picea sitchensis*, *Thuja plicata*, *Tsuga heterophylla*, together with such shrubs as *Sambucus racemosa* soon follow the cutting of the timber. Far up the valley, where the forest is partly cut, seedlings of *Pseudotsuga mucronata* cover the cleared land. In the side valleys, where there is a pure stand of hemlock (*Tsuga heterophylla* and *T. mertensiana*), seedlings of these follow the partial cutting of the timber.

6. VEGETATION ON BURNED AREAS

About 30 years ago there was a severe fire in the Bella Coola region. Since that time there have been no fires of any extent in the

valley, and therefore there was no chance to study the successions that follow recent burns; but present conditions of areas that were burned 30 years ago were studied.

On the mountain side that faces south the burned areas are grown up to an almost pure stand of *Pseudotsuga mucronata*. Where the ground is rocky *Pseudotsuga* is replaced by *Pinus contorta*. The trees are so crowded that some of them are dead, and the shade is so dense that there is little or no vegetation under the trees. The scattered growth consists of *Aralia nudicaulis*, *Arctostaphylos uva-ursi*, *Pyrola minor*, *P. asarifolia*, *Rubus parviflorus*, and a few trees of *Alnus rubra* and *Acer glabrum*.

Where the burned area has a west exposure, under the *Pseudotsuga* occur *Rubus parviflorus* and seedlings of *Tsuga*, *Picea*, and *Thuja*. Conditions on the western exposure are much more mesophytic than on the southern exposure. Where burned areas face north, conditions are very different. Large areas are covered with *Alnus sitchensis*, *Amelanchier alnifolia*, and *Acer glabrum*. Under the deciduous trees are seedlings of *Picea*, *Tsuga*, and *Thuja*. Sometimes both *Tsuga heterophylla* and *T. mertensiana* are found. The deciduous vegetation is much more marked on the north facing mountain than it is on the south facing slopes. At the eastern end of the valley, on a small recently burned area, small *Pseudotsuga* trees cover the ground. On rocky places *Pinus contorta* replaces the *Pseudotsuga*.

Vegetation on eroding surfaces

There are two types of eroding surfaces in the Bella Coola region, glacial terraces in the side valleys that open into the Bella Coola Valley and river terraces along the sloughs through which the flood waters of the Bella Coola River flow during times of flood.

Many of the side valleys were preglacial and filled with gravel at the end of the ice age. Since that time mountain streams have been eroding them, in some places the erosion still occurring. Trees of *Tsuga* are found sliding down such banks, and they grow poorly. The only pioneer tree on such steep slopes is *Alnus rubra*. Such banks are open and exposed to erosion. Along the sloughs the flood waters have cut as many as two or three terraces. *Alnus rubra* constitutes 80 per cent of the tree growth, and *Salix scouleriana* and *S.*

lasianandra 20 per cent. These trees are the pioneers, and under them come *Sambucus racemosa*, *Lonicera involucrata*, *Rubus parviflorus*, and *Symphoricarpus racemosa*. Herbs are not common, *Erigeron philadelphicus* and *Montia sibirica* and in shadier places *Circaea alpina* being found most frequently. *Acer glabrum* and seedlings of *Thuja plicata* and *Picea sitchensis* are found under the willows and alders on the banks.

Mountain vegetation

A detailed study of the vegetation of the mountains of the region and a study of the succession of vegetation on Canoe Crossing Mountain were made. Canoe Crossing Mountain is a part of the northern rim about 20 miles up the valley. It is not a high mountain, being about 1829 m. above sea level. Because of the latitude this is well above the timber line, and affords an excellent study of the alpine and subalpine regions. The vegetation at the top will be discussed first, because all of the vegetation of the mountain has developed since the melting of the glacial ice. The top of Canoe Crossing Mountain has been thoroughly glaciated, as is shown by the glacial grooves, glacial striae, volcanic and other erratics. The glacial grooves show that the valley glacier rode up over the end of the mountain.

1. SNOW FIELDS

Near the top of the mountain, especially in sheltered places on the northern and eastern exposures, there are large banks of perpetual snow. This snow is dimpled from exposure to wind and sun. Red snow (*Chlamydomonas nivalis*) is common on these snow fields. This alga extends deeply into the snow and is better developed in the hollows than on the little ridges between the depressions. The snow fields with northern exposure are thoroughly red with the algal growth. The amount of *Chlamydomonas* on the snow with eastern exposure is still less. On snow fields facing west and south there is little or none.

2. SUCCESSION IN ALPINE REGION

BED ROCK.—At the top of the mountain there is much bed rock that is exposed to the action of light, wind, and cold. The important crevice plant is *Silene acaulis*. If bed rock is more or less vertical

and well drained, three crustose lichens are the pioneers. They are *Rhizocarpon geographicum*, *Acarospora* sp., and an unidentified lichen. The crustose lichens may be overgrown by a small, black fruticose lichen, *Alectoria divergens*, or by a larger black foliose lichen, *Gyrophora erosa*. Sometimes the latter follows *Alectoria*. On the most exposed parts of the bed rock there is no further stage in the succession.

Where bed rock has been hollowed out by ice, and snow lies until late in the spring, the pioneer is a dark colored moss. *Saxifraga tolmiei* starts in the moss if it is sufficiently wet. Where the moss dries out early in the season *Crocynia* sp., a sorediose lichen, may cover the moss. *S. tolmiei* is followed by *Carex tolmiei*, and it in turn is followed by *Luzula parviflora*, *Juncus subtriflorus*, *Poa alpina*, *Phleum alpinum*, *Trisetum spicatum*, and *Veronica alpina*. In most cases the next association is one of *Spiraea pectinata*, which is followed by *Phyllodoce glandulosa* and *Cassiope mertensiana*. Then follows the climax of the alpine region, *Phyllodoce empetriformis*. With this is *Lycopodium sitchense*. In some of the basin areas the succession goes no further than *Cassiope mertensiana*.

Where the alpine region, which is characterized by the absence of upright trees, merges into the subalpine region with its dwarfed but upright trees, the heather on rocky areas which are exposed to the wind is followed by a poor growth of wind timber made up of *Abies lasiocarpa*, *Pinus albicaulis*, and *Juniperus communis*.

TALUS SLOPES.—Most of the mountain is made up of talus. There may be streams, or the water may spread out into shallow pools. In some places the talus is dry throughout the growing season and in other places it is always wet. Along streams that are deep with rather rocky banks are two pioneers, *Caltha leptosepala* and *Trollius laxus*. *Mimulus alpinus* and *Parnassia fimbriata* sometimes grow with them. On higher ground is *Spiraea pectinata*, which in turn is succeeded by the three heathers with *Phyllodoce empetriformis* and *Lycopodium sitchense* as the climax.

Where the running water spreads out into a thin sheet over the talus, mats of moss fill up the water. *Romanzoffia sitchensis* grows in such wet places. Where the moss is not so boggy *Saxifraga tolmiei* occurs. Boggy places in the talus usually have a dense growth of

vinelike willows, *Salix arctica* and *S. barclayi*, around the edge. Back from such places is the usual succession of *Spiraea pectinata* and the three heathers.

Where the talus slope becomes dry in the early part of the growing season certain mosses are the pioneers. These are followed by a growth of lichens, of which *Crocynia* sp., *Cetraria islandica*, and *Cladonia pyxidata* are the most prominent. Sometimes *Cladonia rangiferina* is found also. *Solorina arctica* and another large green foliose lichen soon overwhelm the smaller lichens and the moss. Usually the series is ended by a dense growth of fruticose lichens, among which may be mentioned *Stereocaulon tomentosum* and a *Cladonia*.

The mosses and the lichens are followed by flowering plants, such as *Saxifraga tolmiei* and *Gentiana propinqua*. In some places the following make a colorful mat, rooted in the moss: *Sibbaldia procumbens*, *Saxifraga bronchialis*, *Pentstemon confertus*, *Pedicularis scopulorum*, *Senecio pauciflorus*, *Oxyria digyna*, *Saxifraga lyallii*, *Pedicularis scopulorum*, *P. bracteosa*, and many others. Often *Campanula rotundifolia* grows in the talus around imbedded large rocks. *Silene acaulis* may sometimes be a pioneer between pieces of talus. Behind the herbaceous associations there always comes *Spiraea pectinata*, followed by the three heathers with *Phyllodoce empetri-formis* as the climax.

Some parts of the talus are kept wet throughout the summer by the melting snow. The water is below the surface of the talus and is moving downward all the time. On such places is the best development of the lupine fields. In the wettest places are quantities of *Trollius* also. Several species of *Castilleja* occur, and where it is very wet there may be found creeping willows. Back from such places, where the talus is better drained, occurs the regular succession of *Spiraea pectinata* followed by *Phyllodoce glandulosa*, *Cassiope mertensiana*, and *P. empetri-formis*. With the heather there may be *Lycopodium sitchense*.

The pioneers that come in the alpine region depend upon the amount of water and upon the condition of the rocks, but in all parts of the alpine region on Canoe Crossing Mountain, every sere ends with *Spiraea pectinata*, followed by *Phyllodoce glandulosa*, which in

turn is followed by *Cassiope mertensiana* and the climax species *Phyllodoce empetriformis*.

3. SUCCESSION IN SUBALPINE OR HUDSONIAN ZONE

At an altitude of about 1585 m. the alpine region merges into the subalpine or Hudsonian zone. This zone extends down the mountain to about 1463 m. Altitudinally it covers about 122 m. On Canoe Crossing Mountain the subalpine zone covers considerable area because the mountain at this altitude is rolling and not at all steep. It has a parklike appearance, with scattered clumps of trees and much low heather. Where the alpine region merges into the subalpine there is a good growth of wind timber, consisting largely of *Abies lasiocarpa* and *Juniperus communis*. Somewhat lower down the trees are upright, but have no branches on the windward side.

Some of the lakes in the subalpine area are deep, with rock bottoms. Around such lakes is *Spiraea pectinata*. In the upper part of the subalpine the *Spiraea* is followed by *Phyllodoce glandulosa*, but in the lower part this is absent and the *Spiraea* is followed by *Cassiope mertensiana*. *Phyllodoce empetriformis* follows *Cassiope*. In the upper part of the zone this species gives way to clumps of trees, mainly *Abies lasiocarpa*, together with a few *Pinus albicaulis*. However, in most of the subalpine area *Phyllodoce empetriformis* is followed by *Rhododendron albiflorum*, *Vaccinium caespitosum*, and *Veratrum viride*. This shrub association is followed by tree growth.

Shallow lakes usually fill up with mats of moss which appear to be rather solid, but which are not safe to walk upon. In this moss, *Caltha leptosepala* and *Trollius laxus* are usually found. *Salix arctica*, *S. barclayi*, and *S. barrattiana* grow around these ponds. They are usually taller on the west sides of such lakes than they are on the east, because the subalpine zone of Canoe Crossing has a western and southern exposure, and the snow on the western side may melt earlier than the snow on the eastern sides. The willows may be vine-like on the east side of such a lake and several feet high on the west side. Around such lakes the succession goes from *Spiraea pectinata* to trees in the order already discussed.

Sometimes the streams that flow through the subalpine region are slow and sluggish. Along such streams are quantities of moss in

which *Caltha* and *Trollius* grow. With them *Saxifraga tolmiei* may be found. Beyond the edges of such boggy places is *Spiraea pectinata*, followed in the regular way by the heathers and *Rhododendron*. In the lowest part of the subalpine area *Pyrus occidentalis* may grow with the *Rhododendron*. These shrubs and small trees are followed by *Abies lasiocarpa*. When streams flow through rocky channels, the pioneers are *Trollius laxis* and *Caltha leptosepala*. *Phyllodoce empetriforinis* occupies a large area in this region.

Sometimes the streams are shallow and spread over rocky areas. Here are produced the beautiful wet meadows similar to those in the alpine zone. *Caltha* and *Trollius* are often in the wettest places. Where there is less moisture there are clumps of *Lupinus arcticus* and *Castilleja*. The lupines are succeeded by the heathers and *Veratrum viride*. Where the ground is perfectly level the lupines are often lacking.

In subalpine ravines there is a marked difference on the west facing and east facing sides. The east exposure may be in the condition of the alpine and the west exposure be so thickly covered by alpine firs as to suggest the Canadian or montane zone. The difference is due to the fact that the snow melts more rapidly on the west slope in the early summer. All the firs in the subalpine region, as well as those lower down, are overgrown by *Alectoria fremontii*. In many places there are rocky ledges exposed to the wind where the wind timber grows and the vegetation is alpine rather than subalpine.

4. VEGETATION IN MONTANE ZONE

PIPER (7) states that the Canadian zone is the most poorly defined zone in the state of Washington. The most characteristic tree in Washington is *Pinus monticola*. *Abies amabilis* and *Tsuga heterophylla*, and sometimes *Thuja plicata*, are also found in the Canadian zone of Washington. On Canoe Crossing Mountain the montane zone extends from about 853 m. to about 1463 m. (fig. 5). The montane zone is made up of three great bands of forests, each occurring as an almost pure stand of a single species. The uppermost band of trees is a forest of *Abies lasiocarpa* with a few scattered specimens of *Pinus albicaulis* and *Tsuga mertensiana*.

Around Mud Lake, which is in the upper part of the montane,

the succession of vegetation is as follows. The open water of the lake is full of a brown floating moss (*Amblystegium*). The first zone

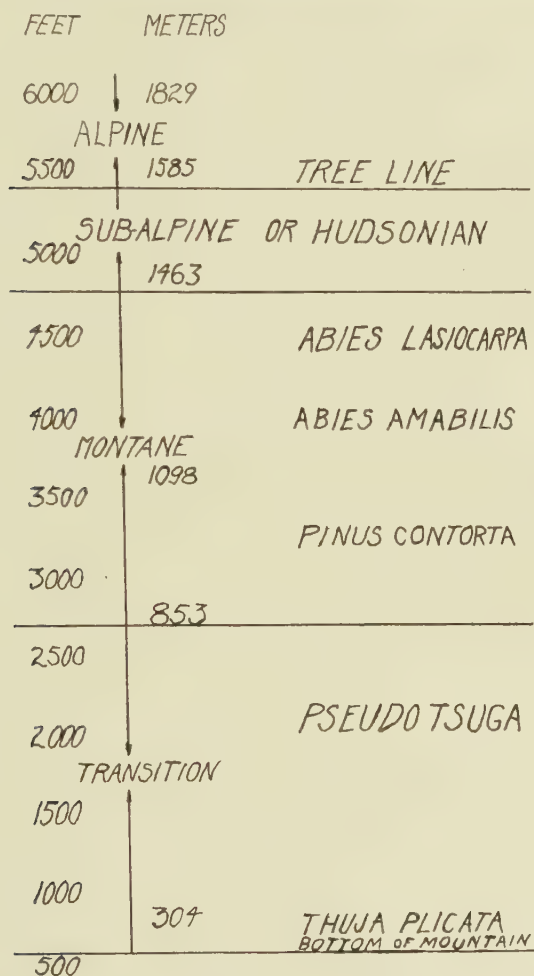


FIG. 5.—Profile of Canoe Crossing Mountain showing dominant vegetation at different altitudes.

of plants rooted in the mud beneath rather deep water is *Carex rostrata*. Closer to the shore is *Eriophorum polystachion*. Shoreward from that is a close growth of *Sphagnum* and other mosses in which

is growing *Carex decidua*. An association of *Carex phaeocephala* follows this. With it is *Poa alpina*.

Out of the reach of water during most of the growing season is a wide and well developed zone extending entirely around the lake, made up of *Spiraea pectinata*, *Luzula dicaricata*, *Veratrum viride*, *Valeriana sitchensis*, *Deschampsia atropurpurea*, and several composites.

The two heathers, *Phyllodoce glandulosa* and *Cassiope mertensiana*, which usually follows *Spiraea* in the alpine and subalpine regions, have been eliminated and *Spiraea pectinata* is followed by *Phyllodoce empetriformis* in the upper part of the montane zone. *Phyllodoce empetriformis* was not found below 1310 m. Around Mud Lake the heather is followed by *Rhododendron albiflorum*, *Pyrus occidentalis*, *Veratrum viride*, and *Lupinus arcticus*. This association is succeeded by *Abies lasiocarpa*, growing so densely that there is little or no undergrowth. At about 1310 m. the band of alpine firs gradually merges with a forest of *A. amabilis*. This species forms an almost solid stand down to 1098 m. The lower part of the forest gradually merges into a forest of *Pinus contorta*, which extends from 1098 to 853 m. Most of the trees are 0.3 m. in diameter and are tall and well developed. The pine forest gradually merges into the transition zone below.

5. TRANSITION ZONE

On Canoe Crossing Mountain much of the soil is made up of small talus material. The slope, although steep, is remarkably free from gullies. There are a few areas of bed rock, but on the mountains west of this elevation are many large areas of exposed rock. There are a few canyons on the mountain side. The lower 200 feet of the mountains that face the south are mesophytic.

Canoe Crossing Mountain begins to rise from the Bella Coola Valley at about 244 m. above sea level. From about 305 m. above sea level the mountain is dominated by *Pseudotsuga*, except on rocky areas. Some of the trees are giants and others are second growth. The lower part of this forest is open and easy to traverse. There is a scattered growth of *Pachystima myrsinites*, *Arctostaphylos uva ursi*, *Epilobium angustifolium*, *Spiraea discolor*, *Shepherdia canadensis*, and a few other species. The north sides of the trees,

but never the south sides, are covered with a long yellow fruticose lichen. Above 487 m. the undergrowth is much denser, and consists of the preceding species, together with *Pteris aquilina*, *Rubus parviflorus*, and *Cornus canadensis*. Where the shade is thick *Polypodium vulgare*, *Pyrola* sp., and other species occur. Deciduous trees are more in evidence, and *Alnus tenuifolia*, *Amelanchier alnifolia*, and *Acer glabrum* are found. In the more open parts of the forest are young trees of *Pseudotsuga*. In shady parts the undergrowth consists of young trees of *Thuja plicata* and *Tsuga heterophylla*. These species seem to be succeeding *Pseudotsuga*, especially where there is sufficient shade. Often the benches on the sides of the mountain are covered with a very mesophytic forest.

Much of the slope of the south facing mountains is made up of bed rock. Such areas are covered with many kinds of mosses, including *Gymnostomum* sp., *Rhytidium robustum*, *Racomitrium canescens*, and *Mnium insigne*. Almost never does one find *Hylocomium splendens* on the south facing slopes, although it is common on the floor of the valley.

In the mossy areas are patches of *Peltigera*, *Cladonia*, and *Selaginella rupestris*. In summer the patches of mosses have a red brown color and may be seen at great distances. *Cryptogramma acrostichoides* and *Polypodium vulgare*, *Campanula rotundifolia*, *Sedum*, and *Epilobium angustifolium* are also found on the moss covered rocks.

Some of the rocks are covered with shrubs, such as *Pachystima myrsinites*, *Menziesia ferruginea*, *Amelanchier alnifolia*, and *Acer glabrum*. *Pinus contorta* occurs on these rocky areas. Its roots are shallow and able to spread out over the rocks.

Near the bottom of the mountains the forest is very mesophytic. *Pseudotsuga* is mixed with *Thuja plicata*, *Picea sitchensis*, *Alnus rubra*, *Populus trichocarpa*, and *Acer glabrum*. The shrubs of this forest are *Cornus stolonifera*, *Physocarpus*, and *Spiraea discolor*.

The ravines and canyons on the mountain sides are filled with *Fatsia horrida*, *Menziesia ferruginea*, and *Vaccinium ovalifolium*. The tree growth is dense, and consists of *Thuja plicata* and *Acer glabrum*.

6. NORTH FACING MOUNTAINS

The mountains that border the south side of the Bella Coola Valley are much more dissected by small streams and little valleys than are the mountains along the north side of the valley; therefore there are more west, northwest, east, and northeast facing slopes than there are due north exposures. These variations are significant, and are quickly reflected in the species of conifers that are dominant on any particular area.

The west exposure of the lower part of the mountain is covered with a mesophytic forest in which *Thuja plicata* makes up about 35 per cent of the trees, *Tsuga heterophylla* and *T. mertensiana* 20 per cent, *Picea sitchensis* 18 per cent, *Alnus rubra* 10 per cent, *Pseudotsuga mucronata* 8 per cent, *Betula occidentalis* 5 per cent, *Acer glabrum* 3 per cent, and *Populus trichocarpa* 1 per cent. The specimens of *Picea*, *Thuja* and *Tsuga* are large too, but they are not so gigantic as *Pseudotsuga*.

There is dense shade in such a forest and the ground is thickly covered with *Mnium* and *Hylocomium*. The ferns are, *Phlegopteris dryopteris*, *Asplenium cyclosorum*, *Aspidium spinulosum*, and *Polystichum munitum*. Such shrubs as *Viburnum pauciflorum*, *Rubus parviflorus*, and *Aruncus sylvestris*, and such herbs as *Actaea cuneata*, *Chimaphila umbellata*, and several species of *Pyrola* form a scattered growth.

Well up on one of these mountain slopes with a western exposure is a bench along a mountain stream where there is growing a small group of *Populus tremuloides*. This is the only place in the whole region where this species is known to occur.

Where the mountain faces due north, the forest is made up almost entirely of *Tsuga heterophylla* and *T. mertensiana*. The ground under these trees is completely covered with many kinds of lichens and moss. The most prominent of these are *Peltigera*, *Cladonia*, and *Hylocomium*. Carvings made by the Indians on big boulders and bed rock have been entirely covered with the moss and lichen growth.

On the lower part of the mountain, where large areas of bed rock are exposed, especially where the surface of the rock slopes steeply, *Pinus contorta* is the edaphic dominant. Where the mountain slope

has an east exposure, especially when the side valleys are narrow and the slope is protected from the sun, the forest consists of *Tsuga* intermingled with *Abies grandis*. In such situations the moss is very thick. The snow lies deeply on the ground in the winter and remains until late in the spring. Much moisture is retained in the moss from the snow, rains, and fogs. The *Tsuga-Abies* forest of these east slopes may be considered a post-climax in the region.

No study of the upper slopes of the north facing mountain was made, but residents of the valley who have been on top of these mountains say that the alpine region is covered with the same kinds of heather as are found on the south facing mountains.

Wherever the north facing mountains were burned, some 30 years ago, the slopes have grown up to deciduous vegetation consisting of *Acer glabrum* and *Alnus sitchensis*. Under the trees are halfgrown trees of *Picea sitchensis*, *Thuja plicata*, *Tsuga heterophylla*, and *T. mertensiana*. Such a forest is difficult to traverse, and contrasts strongly with the open *Pseudotsuga* forest on the south facing slopes, which has also grown up since the fire 30 years ago.

Side valleys

The large side valleys that open into the Bella Coola Valley extend in a north and south direction. It is evident that some of them have been preglacial, because they are filled with glacial terraces. Salloompt Valley opens from the north, and its southern end is wide for at least 2.5 miles north of the Bella Coola River. Then the valley becomes narrower and the glacial terraces become prominent. Deep snow lies in the valley in winter, but in early spring the snow melts sooner than it does in the Bella Coola Valley, and for this reason the vegetation of the south end of Salloompt Valley is much more advanced in the spring than vegetation of the Bella Coola Valley.

At the southern end of Salloompt Valley are areas that are grown up to an almost pure stand of *Pseudotsuga*. Farther to the north the forest is more mixed. Large trees of *Picea sitchensis*, *Thuja plicata*, and *Tsuga heterophylla* make up the forest. The undergrowth consists largely of *Tsuga*. Apparently the *Tsuga* forest is a post-climax for the region.

On the terraces the forest consists of *Tsuga* 64 per cent, *Pseudo-*

Tsuga 17 per cent, *Thuja plicata* 10 per cent, *Pinus contorta* 2 per cent, *Betula* 1 per cent, *Picea* 4 per cent, and *Alnus rubra* 2 per cent. Openings in the forest are covered with *Pteris aquilina* var. *lanuginosa*. Most such forests have little undergrowth except *Hylacomium*. What there is, is scattered and consists of *Linnæa borealis*, several species of *Vaccinium*, and several kinds of *Pyrola*.

The valleys that open into the Bella Coola Valley from the south retain the snow until late in the spring, and the vegetation is apt to develop later than does vegetation in the Bella Coola Valley. The forests in these shaded and very mesophytic valleys consist largely of *Tsuga heterophylla* and *T. mertensiana*, together with *Abies grandis*. All north and south valleys are characterized by the absence of *Populus trichocarpa*. *Fatsia horrida* is common close to the streams, and in openings.

Floristics

When the continent of North America was cut into two parts by the great Rocky Mountain geosyncline in the Cretaceous period, western North America was a peninsula of Asia, and the eastern part of the continent was attached to Europe. HARSHBERGER (5) states that it was at that time that the eastern and western conifers were assorted and established as distinctly eastern and western species. In the Bella Coola region there is only one species of conifer that is found in the eastern part of the continent. This is *Juniperus communis*, and it is found only in the alpine and subalpine zones, where it occurs as wind timber.

PIPER (7) says that the facts in the distribution of *Picea sitchensis* are peculiar. It is the dominant tree, forming more than 50 per cent of the forest strip along the coast from middle Oregon northward to Kodiak Island, beyond which all timber ceases and the flora becomes that of the Arctic zone. In the north this species ends sharply in the Arctic meadows, and in the south it merges gradually with the *Pseudotsuga* forests. This enormous stretch of a single species at sea level is probably due to the remarkably equable temperature and great humidity of the immediate sea coast. According to WHITFORD and CRAIG (10), *Picea sitchensis* is confined to the Pacific Coast, seldom extending back farther than 50 miles from the salt water. It seldom occurs in a pure stand, and is a prolific seeder.

Abies grandis occurs rarely in the Bella Coola region. It is found in the side valleys that open into the Bella Coola Valley from the south. These valleys are closely shaded by the mountains and open to the north, and they are deeply filled with snow until late in the spring. *Abies grandis* does not occur in a pure stand, but is always found growing with *Tsuga heterophylla* and *T. mertensiana*. Mr. F. Jacobsen, who lives in the valley, says that *Chamaecyparis nootkatensis* is found in only one place in the Bella Coola region, and that is far up in one of the mountains along the northern border at the western end of the valley.

There are only two pines found in the area studied. *Pinus albicaulis* grows in the alpine and subalpine zones but not abundantly. *P. contorta* grows as an edaphic pioneer on rocky places, and is found abundantly in the montane zone. *Pseudotsuga mucronata* evidently has come into the Bella Coola Valley from the interior plateau, and is found at its best at the eastern end, where the climate is more continental than it is nearer the coast.

Both *Tsuga heterophylla* and *T. mertensiana* grow together in the valley and on the north facing slopes. In the valley bottom *T. heterophylla* is much the commoner of the two in the mixed forest.

The poplars of the region are interesting. *Populus trichocarpa* is the common species. It is a pioneer on damp ground along streams, and is almost the ecological equivalent of the willows in the seedling condition, but in the climax forest the poplars are present as hangers because they are long-lived trees. *P. trichocarpa* is seldom or never found in any of the north and south valleys. For its establishment as a seedling it needs strong light as well as moisture. Sufficient light is not available in north and south valleys. *Populus tacamahaca* is found rarely in the valley. It is a pioneer on cutover land that has been pastured. *P. tremuloides* is found in but one place in the Bella Coola region. It grows on one of the mountains that borders the south side of the valley, along a mountain stream.

There are two willows in the valley and three in the alpine and subalpine parts of the mountains. The two species of low altitude are *Salix lasiandra* and *S. scouleriana*. The three species of the mountain tops are *S. arctica*, *S. barrattiana*, and *S. barclayi*.

The ferns of the region are cosmopolitan. *Asplenium trichomanes* grows in about 25 clumps on the large rock slide at the western end of the valley. Only this station was found for it. *Botrychium simplex* and *B. ramosum* were found in one location, but since they are so small they may have been overlooked in other places.

Many species of heaths are common, but the distribution of *Gaultheria shallon* is the most outstanding of all. It is found in only one place in the region. It grows on the west exposure of a mountain at the western end of the valley along the northern rim. Here it occurs in the shade of the coniferous forest, and makes traveling through the forest difficult. This very local growth, as contrasted with its common and widespread occurrence along the channels farther west, is noteworthy.

Lichens are abundant everywhere. They cover the fence posts, tree trunks, tree limbs, and rocks from sea level to the mountain tops. No *Fucus* is found in the waters of North Bentnick arm near the mouth of the Bella Coola River. This species is common along the coast, and its absence here is noteworthy and is probably due to the dilution of the saline waters of North Bentnick by the fresh water of the Bella Coola River.

This work was done under the direction of Dr. HENRY C. COWLES, and to him I wish to express thanks for advice and for the loan of certain instruments. I am also indebted to Dr. GEORGE D. FULLER for much valuable help and for the loan of instruments, to Dr. BRUCE FINK and to Dr. CHARLES PLITT for identifying the lichens, to Dr. JOHN DAVIDSON for identifying certain of the herbaceous species, and to Miss MILDRED IRWIN for identifying certain of the mosses.

ILLINOIS STATE NORMAL UNIVERSITY
NORMAL, ILL.

[Accepted for publication January 6, 1931]

LITERATURE CITED

1. DALY, R. A., Our mobile earth. C. Scribner's Sons. 1926.
2. DOLMAGE, V., Coast and Islands of British Columbia between Burke and Douglas channels, Summary Report, 1921. Part A, Dept. Mines, Canada. 1922.

3. ———, Tatla-Bella Coola area, Coast District, B. C. Summary Report, 1925. Part A, Dept. Mines, Canada. 1926.
4. FULLER, G. D., and BAKKE, A. L., RAUNKIAER's Life forms, Leaf-size classes, and Statistical methods. *Plant World*, 21:25-63. 1918.
5. HARSHBERGER, J. W., *Phytogeographic survey of North America*. Leipzig and New York. 1911.
6. LINDGREN, W., *The igneous geology of the Cordilleras and its problems*. Yale Univ. Press. 1915.
7. PIPER, C. V., *Flora of the State of Washington*, Contr. U.S. Nat. Herb. Washington. 1906.
8. RAUNKIAER, C., *Recherches statistiques sur les formations végétales*. Det. Kgl. Danske Videnskabernes Selskab. *Biologiske Meddelelser* 1:3. København. 1918.
9. SPENCER, A. C., *The Pacific Mountain system in British Columbia and Alaska*. *Bull. Geol. Soc. America* 14. 1903.
10. WHITFORD, H. N., and CRAIG, R. D., *Forests of British Columbia*. Comm. Conservation, Ottawa, Canada. 1918.

